

NOTES ON SOME DIGGER BEES.—I.

BY JOHN B. SMITH, SC.D.

One of the most interesting collecting regions that I have ever found is in the New Jersey Pines. At first sight there is nothing very attractive about them—mostly sand, covered by oak scrub or briars, fields or opens of Indian grass, stunted pines, then a swamp more or less cedar covered, from which runs a little stream through a lowland which is very apt to be in cranberries. The impression gained from the car windows riding to Atlantic City, Cape May or other shore resorts, from New York or Philadelphia, is of dreary desolation, intense heat in summer, flocks of mosquitoes and general hopelessness. Yet this impression is utterly erroneous. There is more difference in level than first appears and, while there are no high hills, there is fall enough for rapid streams affording water power for numerous mills—many of them now dropping to pieces and disused. There are really many very pretty bits of quiet landscape and here and there a large pond courteously dubbed a “lake” affords fishing and even rowing. Lakewood and Browns Mills are Pine resorts not unknown to the fashionable world, but they are by no means the best points in the region. To the naturalist this area is of never-failing interest. The flora which at first seems so uniform is really very rich and varied; while as to insects the records in my Catalogue of the species found in New Jersey will indicate something of the faunal wealth.

Years ago I became acquainted with Mr. J. Turner Brakeley, of Bordentown, N. J., who spends each season, a large portion of his time in the pines, in Ocean County. There are cranberry bogs there and in the course of my studies on the insects injuring this crop I spent some time at Lahaway, as Mr. Brakeley's place is called. This is well in the pines, several miles from any railroad, and two miles or more from the nearest group of houses dignified by the name of village—Prosperdown, in which nobody prospers.

Mr. Brakeley knows the pines and their inhabitants; knows much of botany and something of entomology; but better than all, he has the faculty of close observation. Almost every year for a long time past I have managed to spend a few days with him, alone with nature—he keeps bachelor's hall—and on our tramps we frequently discussed

the numerous indications of underground life. This particular locality is peculiarly adapted to the requirements of burrowing insects and every road, every opening in the woods and almost every sand field showed little heaps of sand; here, there and everywhere. There is first of all from six to eighteen inches of light drift sand, dry as can be in summer and light enough to blow away on the surface; but moist a few inches down and very compact. Below this comes an admixture of fine clay, often colored by iron to a rusty red, and below this there is usually a layer of gravel or sand or both. Strata follow each other in this way eight feet down and more, on the level, none of them more than a foot or two thick and all easy digging except in the gravel which is sometimes very hard and mixed with iron stone. Bees, wasps, spiders and ants we saw disappearing into holes in the ground and there ended our knowledge of them. Of course I wished to know more and talked learnedly of what little the books said on the subject. Mr. Brakeley listened patiently and finally proposed to get plaster casts of the burrows as the easiest way of finding out the truth. When I proved skeptical as to the feasibility of the plan he tried it quietly after I left and succeeded. He is, therefore, entitled to full credit for the method by which the information, here given, was obtained. After many trials he found that a good quality of plaster was essential to the best results, and I obtained dental plaster for the purpose. This was mixed measure for measure with water, *i. e.*, one ounce measure of plaster was dumped into one ounce measure of water, the mixture was rapidly stirred and poured while perfectly liquid into the surface opening of the burrow to be investigated. The water drained rapidly into the moist soil and the cast set rapidly, some holes taking as much as eight ounces of liquid plaster. This was comparatively easy; the wearisome task was digging out these casts which went down way beyond the limits I had supposed possible. The first work was done on burrows made by spiders, which were large and easily filled; but in 1898 almost the entire summer was put into work with bees.

***Colletes compacta* Cress.**

The determination of this species, which is one of the earliest of its tribe, I owe to Mr. Wm. J. Fox. It is on the wing early in March and its burrows were first noted by Mr. Brakeley on March 12th. At that time groups of from 10 to 20 little mounds of yellow sand were

noticed, indicating a depth of from six to twelve inches. From appearance some of these mounds had been there from 2 to 4 days. They were about $1\frac{1}{2}$ inches in diameter and half an inch high, with a central opening less than one quarter of an inch in diameter. On the 13th over 200 were seen on the same area and on March 15th the ground was dotted with mounds everywhere in groups of from 5 to 15 or more. On this date one of the burrows was followed down to 18 inches without finding the end and several of the bees were taken making determination possible. Plaster casting was now begun and the casts obtained ran from 10 to 17 inches in length, a little twisted or bent near the surface, then dropping down almost vertically. Some burrows, however, were absolutely vertical from the top to the bottom.

March 17th, at a distance of 20 inches from the surface, one cast showed a lateral, set off at an obtuse angle downward from the main gallery.

March 20th a parchment-like cell was found at the end of a lateral. This cell was about three-fifths of an inch in length, less than one quarter of an inch in diameter, a trifle dilated centrally, though this may have been due to removal from soil, was rounded at the outer or lower closed end and squarely truncate at the upper or open end. In texture it was close and very thin, transparent, not very tough, yet scarcely to be called brittle. It was evidently not intended to be resistant, but to keep clean the pasty mass with which it was to be filled.

March 27th to 31st, bees were engaged in filling these food sacs and on April 1st the first completed brood cell with egg in place and finally sealed was found. Of the casts secured up to this time the longest was 27 inches, the range for the beginning of the lateral being from 20 to 27 inches. The laterals themselves varied from 2 to 4 inches, an extreme of 6 inches being observed in rare instances. Cells not sealed were filled with plaster when cast, the membraneous covering forming a shining surface at the end. When sealed the closed cell hung loosely to the end of the cast.

The food stored in the brood cells is a pasty mixture of honey and pollen, but where the insects secured the material at that season was not ascertained. The cell is less than half filled with food and the egg, which is quite large and crescent-shaped, is attached at one side by one end and so curved that the opposite tip rests on the surface of the food mass. The entire insect is less than 11 mm. in length, of

which the female abdomen is rather more than 5 mm. The egg slightly exceeds 3 mm. in length.

The interval from the beginning of the burrow to the time when the first egg is laid seems, therefore, to be from 18 to 20 days, of which 5 were rainy. Three of the 5 bad days came while the insects were storing food and probably delayed the completion of the work. When the cell is filled and an egg is laid the upper end is closed by a flat disc of the same parchment-like material as that constituting the rest of the cell and set in a little inside the ragged upper edge. When completed one of these cells is not unlike in appearance to a short 32 cartridge, and Mr. Brakeley and myself fell into the habit of referring to them as "cartridges" loaded or empty, as they were or were not filled with food. The material of which the pouch is composed is probably altogether salivary. There is no fibrous structure apparent and no mixture of extraneous materials. In casting these burrows the plaster ran to the disc closing the cell, adhered to it and to the slightly projecting rim, so we obtained the perfect cell whenever there was one in place.

The early days of April were unpleasant, rain and snow closing out insect work and leveling the surface so that the location of burrows was not readily visible. However, on the 7th, two casts made showed one loaded and one empty cartridge.

Field work was discontinued until April 22d and now for the first time we ran against a burrow that seemed to have been filled up. It was assumed that this was due to accident, and no further examination was made. It became probable, in the light of later developments, that this was really a completed burrow in which the bee had made all the brood cells that were considered desirable and which had then filled up normally to the top.

April 23d, a number of holes were filled with plaster in a locality marked in March, and these required an unexpectedly small amount of plaster. When the casts were dug out they were unusually short, and some of them had a heel of variable length below the lateral, as if the bee had decided to continue its perpendicular. This was what we expected would happen from published accounts, hence it attracted no special attention. Continuing to dig, however, a second, loaded cartridge, was found below, though not in line with the first, and the burrow leading to it had become filled with sand, which, from its color, had evidently been derived from an upper level. This led to

further investigations, and from a large number of casts and excavations it was found, by April 30th, that the burrows made in March and early April were gradually filling up, and that the heel of the cast below a lateral, indicated the existence of a loaded cell or cells at lower levels. A reëxamination of the casts showed a heel present as early as April 4th. As it happened, a cast had been made on that day which for some reason was not at once taken up. Dug out on the 24th, a heel was found and below it a loaded cell.

April 23d, one cell was found in which the larva had apparently just hatched, but no others of this character were discovered—all were yet in the egg stage. This larva retained the position of the egg for a long time, the mouth parts just touching the surface of the food mass. Many of these cells taken up in the last days of April were undoubtedly placed in the earliest burrows, hence the egg stage is an unusually long one.

By May 1st Mr. Brakeley felt himself justified in writing as follows: "But several facts I have absolutely settled. She digs a very crooked tube, depending on the soil status; but generally starts in on a crook. She first burrows to the full depth to which she is going, begins to pouch at the bottom and the first egg is laid at the bottom. Then she goes upward to start the second pouch. * * * Varies from three to five pouches and then starts again in a new place." Except that we never found more than four pouches connected with any one burrow, all these conclusions were verified by later experience. Of the cartridges secured at this time a number were placed in vials in the hope of securing larvæ and later stages; but in no case did I succeed in getting any beyond the larval stage.

May 13-16th I spent at Lahaway and, although I dug out quite a number of cartridges, all loaded, I found none in which the larvæ had hatched. Nor did I find any new diggings at this time; the *Colletes* period was evidently over for that year, the females had done their work and the brood for the next year was provided for.

Mr. Brakeley's observations as to the rate of digging is that they go down about 5 inches a day. This is easily ascertainable because of the stratification of the sand and clay previously noted. The character of the fresh soil at the surface from each burrow, tells almost exactly how far down the specimen is, when once one is familiar with the sequence of the layers.

June 4th and 5th were again spent at Lahaway, and on this date no

adult bees were observed. They were not found about flowers, in the woods, on the sand fields or in the burrows. They seemed to have disappeared completely and places where they were abundant in March and April showed, as the only signs of their former presence, nothing but discolored patches showing where a mound had been located; the discoloration being due to the clay that had been brought up from lower levels by the bees.

On this point I may say that in my collection I have specimens dated June 1st, taken at Lahaway in previous years, and it may be that in some seasons they fly later than others. All these late examples are males. Of the specimens sent me by Mr. Brakeley in 1898, more than half were males and all were taken late in March or early April going into or coming out of a burrow. It seems, therefore, as if the males sought out the females in their own homes and the females may begin to dig even before they have been impregnated. It seems probable too that the males may live for some time, after no more females are to be found. But on this point it needs continuous observation and collection from the first appearance of the species until no more examples are to be seen.

Starting from a group of the discolored patches already mentioned, and digging a trench two feet deep as a starting point the old burrow may be traced down by the difference in color of the sand; so that first the laterals and afterward the cartridges could be found. In no case did I find more than three cartridges in connection with a single tube: usually there are only two and not infrequently a single one only was found. As to direction from the vertical burrow, the insect rarely places one cell directly above another. In one cast that I dug out a cartridge was found nearly six inches from the main tube in one direction and a second was found almost as far away from the tube in the other. That is, there was a distance of fully ten inches between the two cells, and, in this case, not much difference in level.

From the diggings now made, in one case reaching 28 inches, and from the casts already in hand the habit of the species could be clearly made out. Perhaps it may be as well to say that digging for loaded bee cartridges even where they should be abundant is not so easy a task. As the net result of three hours' digging on one day Mr. Brakeley secured only one filled cell! Of course on other days he did better, but there are a number of probable seekers after this honey store so that, the later in the season it gets, the fewer loaded cells can

be found. In one case a lot of red ants were found robbing the store and where ants are as plentiful as they are at Lahaway, no doubt they are responsible for the disappearance of many bee cells.

It seems certain that *Colletes compacta* digs down from the first to the extreme depth of the burrow; it runs off then, to one side, from two to four or rarely six inches, makes and fills a cell and lays an egg in it. Two or three inches higher another lateral is started, running in a different direction, and the sand taken from this lateral is dropped into the main tube whence it washes into the first lateral so that when the second is completed, the first is pretty well filled up. The second lateral is filled with material from the third if a third is run and, finally, the entire tube is filled; whether gradually by a sifting in of sand from the top, or intentionally by the insect, I cannot say. It is certain, at all events, that the burrows do not remain open and that the young bees that hatch two feet more or less below the surface, must dig up through the soil to that point. Whether they follow the line of the parent burrow in doing this, or whether they work out on lines of their own, is not yet known. One finds in digging about after the new cartridges, old ones that are filled with sand and black with decay. Evidently its old larval home serves the new bee by providing a first space to store the sand removed in getting out. Unless the mother bee lays not over three eggs, she must make two or more diggings.

July 1st, spent part of the morning in digging for more cartridges and as the net result found four in which were larvæ so far developed that they came near to filling the entire cell. Nearly all the food store had been devoured and growth must have been nearly completed. Expecting to secure other examples these larvæ were put into alcohol, but no other specimens were found in spite of all digging. Nor could I secure any others later in the season. The date of pupation is thus left undetermined, and it is also uncertain whether or not the insects reach the adult stage in the fall and winter in the ground, or whether they winter as pupæ and change to adults very early in spring. I would be inclined to believe that the change takes place in fall, because so early as these insects appear, the soil does not feel spring warmth sufficient to induce much active cell development, while it is probably enough to induce an already mature individual to start for the surface.

To recapitulate: *Colletes compacta* makes its appearance—both sexes—prior to March 12th and the females begin at once to dig bur-

rows which extend from 18 to 28 inches down. Males may be taken about these burrows, as well as females. Late in March cells are formed and stored with pollen and honey in the form of a pasty mixture filling less than half the cell. Eggs may be first noted at the beginning of April and none hatch before the end of that month—the majority not until the middle of May or later. At least a month may be counted for this stage. Larvæ are nearly full grown July 1st and probably ready to pupate by the middle of that month; which gives a growing period of from six to eight weeks. Beyond this all positive knowledge ends. Adult males have been taken up to June 1st; females have not been observed after the beginning of May. The bee begins making cells from the bottom of the burrow and works up, never making more than four and rarely more than two cell-bearing laterals from one upright. How many such burrows an individual female may make, is yet indetermined; certainly more than one unless most of the eggs in the ovaries were intended to remain undeveloped.

On this point I examined a number of examples that came in early in the season; I found only a small number of ova indicated; but there are four ovarian tubes on each side, with at least two developing eggs in each tube. There is a third egg cell in each tube, but at the slow rate in which these individual eggs can be placed it is not likely that more than sixteen, perhaps not more than eight ova ever come to maturity. From the specimens examined it appears as if a single egg only developed at one time; at any rate it is certain that there always was only one large egg in one of the tubes, while all the rest were very much smaller. It is probable that the scattering of brood cells is a measure of protection as is also the filling up of the burrows. The honey paste must be tempting to many insects, especially ants, and if six or eight or more cells were grouped around each burrow, the discovery of one series by an ant hill would mean the rifling of every cell in it and the consequent destruction of the entire progeny of a single bee at one time. So the filling up of the burrow makes the discovery of the cells more difficult, the one first planted being protected by the time the lateral for the second is completed.

In the course of the observations on *Colletes* which began earlier than any other form was seen to be on the wing, a few other species were noted incidentally and a few plaster casts of their borings were made. None were followed out as was the *Colletes*, but as the results are additions, though small, to positive knowledge, it is deemed not unnecessary to record them here.

***Andrena vicina* Smith.**

Specimens of this species were collected about flowers early in May and examples came to hand from time to time during that month. May 28th the insects were noticed at work and plaster casts were made on that and next day, May 29th. In the first cast there was only a perpendicular less than a foot in length, without lateral, indicating that the specimen had but recently begun digging operations. In the second there was an empty cell 14 inches below the surface and no filled cartridge could be found lower down. It was evidently the first lateral from the burrow. Another cast was deeper and very crooked, but was no further advanced. Here also there was no appearance of a loaded cartridge below the lateral.

May 31st received five specimens of bees, all females, taken two days before. The ovaries were examined in each case and were found to be undeveloped. They were yet covered or encased in one common sheath and none of the tubes showed either developing or missing ova.

June 4th a number of burrows made by this species were cast. They proved to be very much like *Colletes* in type, but somewhat larger in diameter and decidedly more twisted. They go down a little deeper, also, on the average. *A. vicina* is really a much larger and more bulky insect than *C. compacta*, yet the diameter of the burrow is very little greater.

The cell-making habit seems to be like that of *compacta*; there is the same membranous pouch, filled with the same honey paste, less than half full, with the same sort of egg. What was not noted was whether there were more cells than one from a single main burrow. This species made its burrows on higher ground, more among trees where the soil is filled with roots. This makes their borings more irregular and adds to the difficulty of digging them out.

I have the species from Newark, Jamesburg and somewhere in Burlington County, dated May and June. The Newark locality is indefinite, the specimen was given me and I have no information as to the kind of locality inhabited there. The other specimens were taken by myself in locations generally similar to that at Lahaway.

***Andrena viola* Robt.**

This is a small species resembling *C. compacta* and at first mistaken for it. It was first seen coming out of a hole May 28th and

captured. Plaster cast made of the burrow showed a perpendicular drop of over 15 inches without indication of any lateral. Another, similar burrow, was cast on the same day and the bee inclosed in the plaster. This was shorter than the other, but had a lateral in which was a filled honey pouch, and a heel which indicated a cartridge below. The cartridge was accordingly sought for and found. The conclusion is a fair one that the bee first caught was not digging its first burrow. If my belief that most of these bees change to adults in fall is correct, there should not be much difference in the date at which they issue and begin to dig.

This species was determined for me by Mr. Ashmead and I have specimens from various parts of the State taken May and June, most of them on the latter month pollen-loaded. Unfortunately the day of the month is not indicated, hence cannot say how late in June the species flies.

***Andrena bicolor* Fabr.**

This is nearer to *vicina* in size but readily distinguishable by the rusty thoracic vestiture which made it easy to recognize the bee in the cast. The bee was first seen June 7th, entering a hole larger than usual, and $3\frac{1}{2}$ ounces of liquid plaster were required to fill it. It was nearly perpendicular for 23 inches, then began to twist irregularly, without apparent need, until it measured $38\frac{1}{2}$ inches in length at 30 inches from the surface. There was a cell of the usual composition at the end, loaded with the honey and pollen paste. The lateral at the bottom was not so evident, the tube twisting so irregularly that it seemed like a mere continuation of the twist. That this is not a rule was shown by a second cast made the same day, of the same species. Here there was an almost straight drop of 32 inches then a marked six-inch lateral to the honey pouch.

June 8th, a cast was taken out which dropped down forty inches before forming a short oblique lateral. The loaded cell in this case was fully 41 inches below the surface of the ground and at probably a nearly uniform temperature the year around.

June 11th, two other burrows of this same species were cast. The first included the bee so that no mistake was possible and the cast measured to the honey pouch $37\frac{3}{4}$ inches. There was no heel and no indication that the gallery or burrow had extended below that point. The second cast was twisted so as to measure 34 inches at 30

inches below the surface, where a loaded cartridge was found on a bed of hard gravel. A heel extended from the end of the cast into this gravel, and below it, almost four feet below the surface, another loaded cartridge was found. To this species then, belongs the distinction of making the deepest digging of any species of the genus, and also the boring of the greatest diameter. It is puzzling why this should be so, but so it is.

I have specimens taken at Newark and in Burlington County in May, and a specimen dated Lahaway, June 20th. This is, therefore, one of the later of the species, though *A. hilaris* I have from Lahaway July 17th.

So far I have six species of *Andrena* from Lahaway: *A. hilaris* Sm., April 20–July 17th; *A. vicina* Sm., May and June; *A. bicolor* Fabr., June; *A. nuda* Robt., May and June; *A. salicis* Robt., without date; *A. viola* Robt., April to June.

Notes are here given on the digging habits of three of these, and they are found to be essentially alike, though each has some little peculiarities of its own that would probably show out more markedly on closer observation and more frequent casting.

Halictus, sp.

June 4th our attention was attracted by occasional small burrows, not exceeding an eighth of an inch in diameter. The maker was a small bee, determined by Mr. Ashmead as *Halictus* sp., and only two or three examples were taken.

The galleries drop down vertically about 15 inches, then a little lateral runs off about an inch and a half, at right angles. At the end of this is a drop of about half an inch and then a very pretty little cell, carefully smoothed inside and soaked with saliva or some other secretion. This turns black, the color penetrating quite deeply and cementing the soil particles as far as it extends. At the bottom of this cell is a very handsome ball of dry pollen, shaped like an apple and quite regular.

The desire to complete the history of *Augochlora* made it impossible to devote further time to this species.

There are, it will be noted when the history of *Augochlora* is written, two types of storing diggers; one which makes a paste with honey and pollen stored in a thin membrane-like sac; the other which lines or hardens the inside of the cell and stores the pollen dry in a loaf of definite form. I have little doubt that this difference in habit

will be found to be accompanied by some structural difference that, when once correlated, will serve to determine what the storing habit of the species is.

Though all the species heretofore mentioned were interesting objects of study, all paled before the little blue and green *Augochlora humeralis* which was followed through all its stages.

The life history of that species, with figures illustrating also some of the matters hereinbefore referred to, will form a second part of this essay.

NEW SPECIES OF HETEROCERA FROM TROPICAL AMERICA.—I.

BY WILLIAM SCHAUS.

SYNTOMIDÆ.

Pseudosphex noverca.

Head grayish. Collar black, fringed posteriorly with gray. Thorax black; a transverse gray line posteriorly. Abdomen black; a gray streak laterally at base; ventral valve fringed with white. Wings hyaline, the veins black. Primaries: costal margin broadly, inner margin narrowly on basal half, suffused with dark brown; fringe dark brown. Secondaries: the basal half of costa narrowly suffused with dark brown. Expanse, 27 mm.

Habitat: Castro, Parana.

Bombiliodes jamaicensis.

Palpi and head black. Collar and thorax black; collar and patagiæ with a crimson streak, mottled with white scales, and inwardly shaded with metallic blue scales. Abdomen crimson; a dorsal black band; the segments posteriorly black; underneath pale brown. Thorax below and legs black, the latter streaked with blue; tarsi circled with white. Wings transparent. Primaries: the margins black; the apex broadly black; a large black spot at end of cell touching costa, and a smaller spot about center of cell resting on costa, and not reaching the median vein. Secondaries: apex broadly, outer and inner margin narrowly black. Antennæ black, tips yellow. Expanse, 39 mm.

Habitat: Jamaica.

Bombiliodes xanthogastroides.

Antennæ black, streaked with white at apex. Head black; vertex dark blue. Collar black with two dark blue spots. Thorax black. Abdomen black basally, shaded with blue laterally; the last four segments orange; underneath the last three